Stream Bank Stabilization

What Is It

Stream bank stabilization is used to prevent stream bank erosion from high velocities and quantities of storm water runoff. Typical methods include the following:

- Riprap–Large angular stones placed along the stream bank or lake
- Gabion–Rock-filled wire cages that are used to create a new stream bank
- Reinforced Concrete–Concrete bulkheads and retaining walls that replace natural stream banks and create a nonerosive surface
- Log Cribbing–Retaining walls built of logs to anchor the soils against erosive forces. Usually built on the outside of stream bends
- Grid Pavers–Precast or poured-in-place concrete units that are placed along stream banks to stabilize the stream bank and create open spaces where vegetation can be established
- Asphalt–Asphalt paving that is placed along the natural stream bank to create a nonerosive surface.

When and Where to Use It

Stream bank stabilization is used where vegetative stabilization practices are not practical and where the stream banks are subject to heavy erosion from increased flows or disturbance during construction. Stabilization should occur before any land development in the watershed area. Stabilization can also be retrofitted when erosion of a stream bank occurs.

What to Consider

Stream bank stabilization structures should be planned and designed by a professional engineer licensed in the State where the site is located. Applicable Federal, State, and local requirements should be followed, including Clean Water Act Section 404 regulations. An important design feature of stream bank stabilization methods is the foundation of the structure; the potential for the stream to erode the sides and bottom of the channel should be considered to make sure the stabilization measure will be supported properly. Structures can be designed to protect and improve natural wildlife habitats; for example, log structures and grid pavers can be designed to keep vegetation. Only pressure-treated wood should be used in log structures. Permanent structures should be designed to handle expected flood conditions. A well-designed layer of stone can be used in many ways and in many locations to control erosion and sedimentation. Riprap protects soil from erosion and is often used on steep slopes built with fill materials that are subject to harsh weather or seepage. Riprap can also be used for flow channel liners, inlet and outlet protection at culverts, stream bank protection, and protection of shore lines subject to wave action. It is used where water is turbulent and fast flowing and where soil may erode under the design flow conditions. It is used to expose the water to air as well as to reduce water energy. Riprap and gabion (wire mesh cages filled with rock) are usually placed over a filter blanket (i.e., a gravel layer or filter cloth). Riprap is either a uniform size or graded (different sizes) and is usually applied in an even layer throughout the stream. Reinforced concrete structures may require positive

Source: EPA (1992)

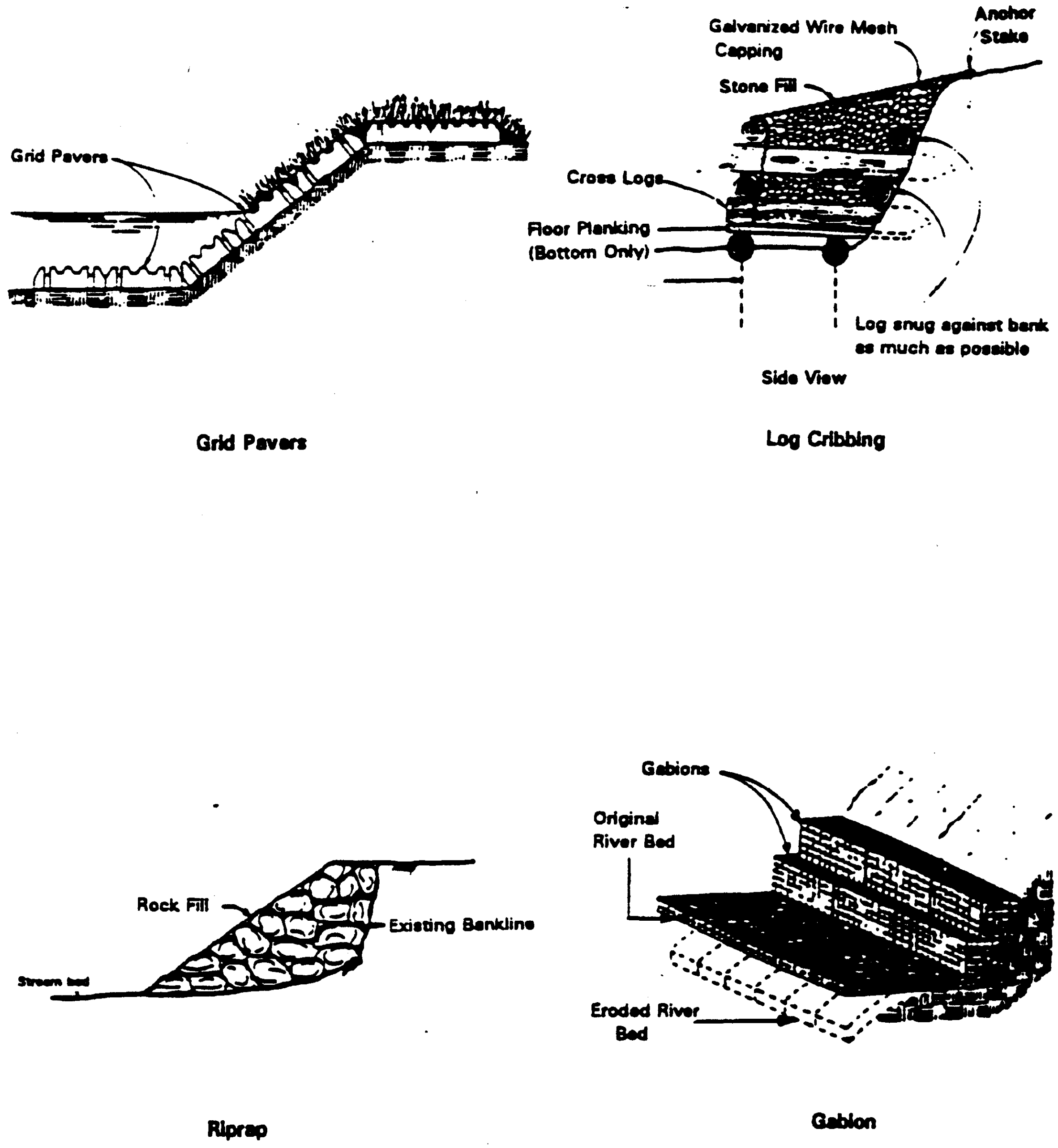

FIGURE A-7 EXAMPLES OF STREAM BANK STABILIZATION PRACTICES
(Modified from Commonwealth of Virginia, 1980, and Commonwealth of Pennsylvania, 1990)

Source: EPA (1992)

drainage behind the bulkhead or retaining wall to prevent erosion around the structure. Gabion and grid pavers should be installed according to manufacturers' recommendations.

Stream bank stabilization structures should be inspected regularly and after each large storm event. Structures should be maintained as installed. Structural damage should be repaired as soon as possible to prevent further damage or erosion to the stream bank.

Advantages of Stream Bank Stabilization
• Can provide control against erosive forces caused by the increase in storm water flows created during land development • Usually will not require as much maintenance as vegetative erosion controls • May provide wildlife habitats • Forms a dense, flexible, self-healing cover that will adapt well to uneven surfaces (riprap)
Disadvantages of Stream Bank Stabilization
• Does not provide the water quality or aesthetic benefits that vegetative practices could • Should be designed by qualified professional engineers, which may increase project costs • May be expensive (materials costs) • May require additional permits for structure • May alter stream dynamics which cause changes in the channel downstream • May cause negative impacts to wildlife habitats

Source: EPA (1992)

Soil Retaining Measures

What Are They

Soil retaining measures refer to structures or vegetative stabilization practices used to hold the soil firmly to its original place or to confine as much as possible within the site boundary. There are many different methods for retaining soil; some are used to control erosion while others are used to protect the safety of the workers (i.e., during excavations). Examples of soil retaining measures include reinforced soil retaining systems, wind breaks, and stream bank protection using shrubs and reeds.

Reinforced soil retaining measures refer to using structural measures to hold in place loose or unstable soil. During excavation, for example, soil tiebacks and retaining walls are used to prevent cave-ins and accidents. But these same methods can be used to retain soils and prevent them from moving. While detailed discussion of soil retaining methods is beyond the scope of this manual, several are briefly described.

- **Skeleton Sheeting**—Skeleton sheeting, the least expensive soil bracing system, requires the soil to be cohesive (i.e., like clay). Construction grade lumber is used to brace the excavated face of the slope.

- **Continuous Sheeting**—Continuous sheeting involves using a material that covers the face of the slope in a continuous manner. Struts and boards are placed along the slope which provide continuous support to the slope face. The material used can be steel, concrete, or wood.

- **Permanent Retaining Walls**—Permanent construction walls may be necessary to provide support to the slope well after the construction is complete. In this instance, concrete masonry or wood (railroad tie) retaining walls can be constructed and left in place.

When and Where to Use Them

Use reinforced soil retaining methods where using other methods of soil retention (e.g., vegetation) is not practical. Some sites may have slopes or soils that do not lend themselves to ordinary practices of soil retention. In these instances, a reinforced soil retaining measure should be considered.

What to Consider

As emphasized earlier, the use of reinforced soil retaining practices serve both safety and erosion control purposes. Since safety is the first concern, the design should be performed by qualified and certified engineers. Such design normally involves understanding the nature of soil, location of the ground water table, the expected loads, and other important design considerations.

Source: EPA (1992)

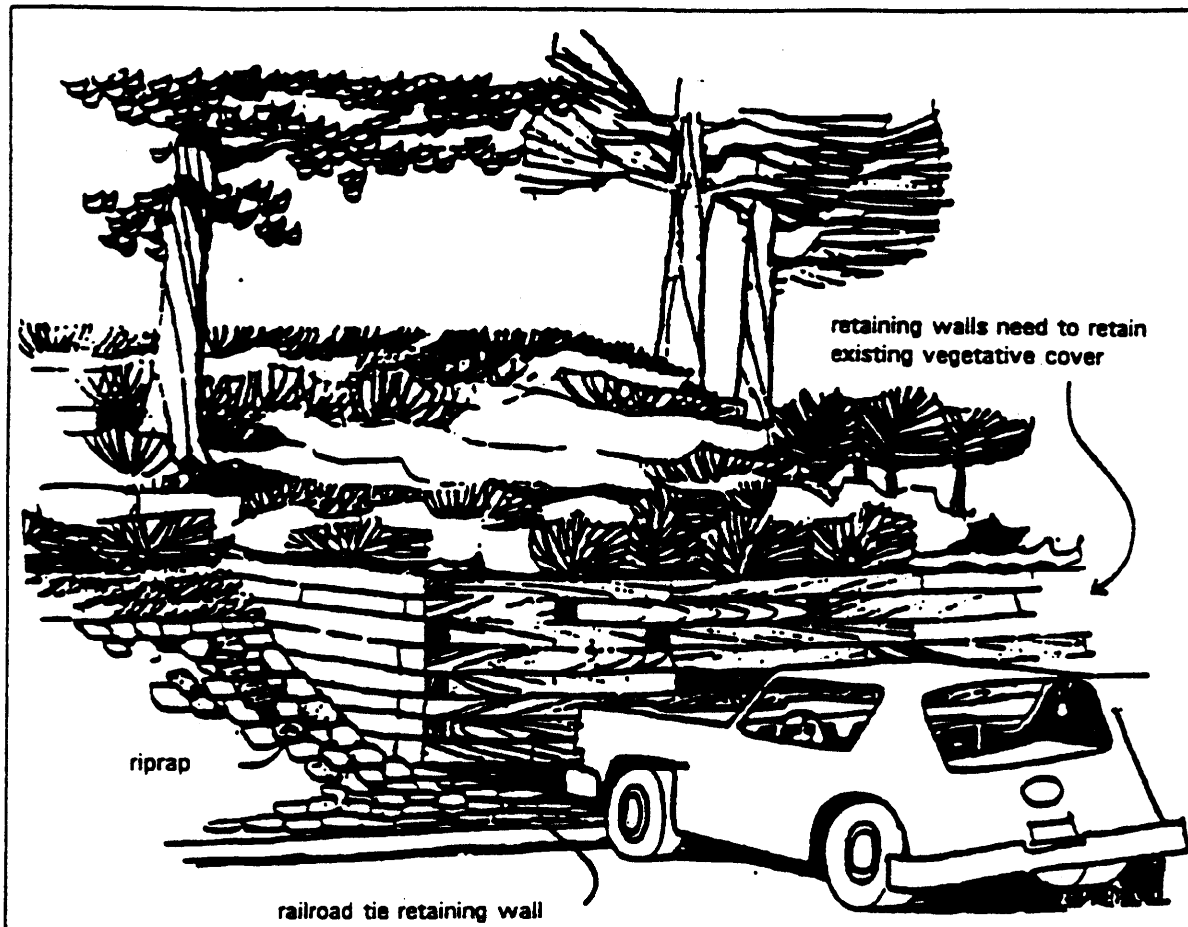

FIGURE A-8 USE OF RETAINING WALLS
(Modification from Washington State, 1992)

Advantages of Soil Retaining Measures
• Provide safety to workers, and some types of reinforced retention can be left as permanent structures • Prevent erosion of soil difficult to stabilize using conventional methods
Disadvantages of Soil Retaining Measures
• Require the expertise of a professional engineer and may be expensive to design and install

Source: EPA (1992)

Dust Control

What Is It

Wind is capable of causing erosion, particularly in dry climates or during the dry season. Wind erosion can occur wherever the surface soil is loose and dry, vegetation is sparse or absent, and the wind is sufficiently strong. Wind erodes soils and transports the sediments offsite, where they may be washed into the receiving water by the next rainstorm. Therefore, various methods of dust control may need to be employed to prevent dust from being carried away from the construction site. There are many ways to accomplish this and some are described below:

- **Vegetative Cover**—For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control (see Temporary Seeding and Permanent Seeding and Planting).
- **Mulch (Including Gravel Mulch)**—When properly applied, mulch offers a fast, effective means of controlling dust (see Mulching).
- **Spray-on Adhesive**—Asphalt emulsions, latex emulsions, or resin in water can be sprayed onto mineral soil to prevent their blowing away (see Chemical Stabilization).
- **Calcium Chloride**—Calcium chloride may be applied by mechanical spreader as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage.
- **Sprinkling**—The site may be sprinkled until the surface is wet. Sprinkling is especially effective for dust control on haul roads and other traffic routes.
- **Stone**—Used to stabilize construction roads; can also be effective for dust control.
- **Barriers**—A board fence, wind fence, sediment fence, or similar barrier can control air currents and blowing soil. All of these fences are normally constructed of wood and they prevent erosion by obstructing the wind near the ground and preventing the soil from blowing offsite.

  Barriers can be part of long-term dust control strategy in arid and semiarid areas; however, they are not a substitute for permanent stabilization. A wind barrier generally protects soil downward for a distance of 10 times the height of the barrier. Perennial grass and stands of existing trees may also serve as wind barriers.

When and Where to Use It

The above measures for dust control should be used when open dry areas of soil are anticipated on the site. Clearing and grading activities create the opportunity for large amounts of dust to be blown, therefore, one or several dust control measures should be considered prior to clearing and grading. One should also note that many of the water erosion control measures indirectly prevent wind erosion.

As the distance across bare soil increases, wind erosion becomes more and more severe. In arid and semiarid regions where rainfall is insufficient to establish vegetative cover, mulching may be

Source: EPA (1992)

used to conserve moisture, prevent surface crusting, reduce runoff and erosion, and help establish vegetation. It is a critical treatment on sites with erosive slopes.

What to Consider

The direction of the prevailing winds and careful planning of clearing activities are important considerations. As a standard practice, any exposed area should be stabilized using vegetation to prevent both wind and water erosion. If your site is located in an arid or semiarid area, you may wish to contact the USDA Soil Conservation Service representative in your area or the appropriate State/local government agency for additional information.

Advantages of Dust Control
• Reduces movement of soil to offsite areas
Disadvantages of Dust Control
• Excessive sprinkling may result in non-storm water discharges from the site

Source: EPA (1992)

STRUCTURAL EROSION AND SEDIMENT CONTROL
BEST MANAGEMENT PRACTICES

Earth Dike

What Is It

An earth dike is a ridge or ridge and channel combination used to protect work areas from upslope runoff and to divert sediment-laden water to appropriate traps or stable outlets. The dike consists of compacted soil and stone, riprap, or vegetation to stabilize the channel.

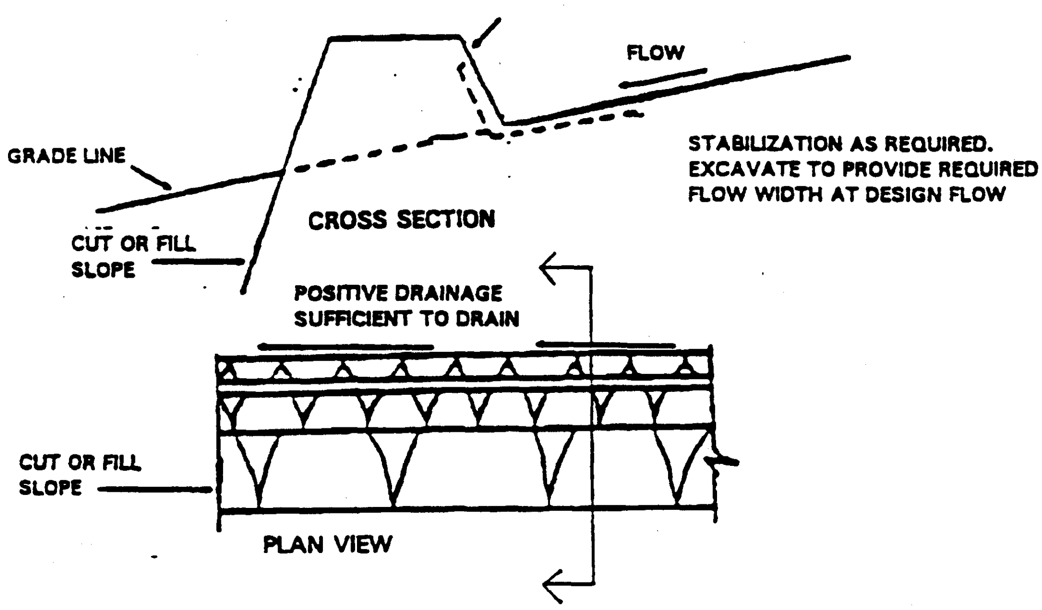

FIGURE A-9 EARTH DIKE
(Modified from Maryland Department of the Environment, 1991)

When and Where to Use It

Earth dikes are used in construction areas to control erosion, sedimentation, or flood damage. Earth dikes can be used in the following situations:

- Above disturbed existing slopes and above cut or fill slopes to prevent runoff over the slope
- Across unprotected slopes, as slope breaks, to reduce slope length
- Below slopes to divert excess runoff to stabilized outlets
- To divert sediment laden water to sediment traps
- At or near the perimeter of the construction area to keep sediment from leaving the site

Source: EPA (1992)

- Above disturbed areas before stabilization to prevent erosion and maintain acceptable working conditions
- Temporary diversions may also serve as sediment traps when the site has been overexcavated on a flat grade or in conjunction with a sediment fence.

What to Consider

Despite an earth dike's simplicity, improper design can limit its effectiveness; therefore, the State or local requirements should be consulted. Some general considerations include proper compaction of the earth dike, appropriate location to divert the intercepted runoff, and properly designed ridge height and thicknesses. Earth dikes should be constructed along a positive grade. There should be no dips or low points in an earth dike where the storm water will collect (other than the discharge point). Also, the intercepted runoff from disturbed areas should be diverted to a sediment-trapping device. Runoff from undisturbed areas can be channeled to an existing swale or to a level spreader. Stabilization for the dike and flow channel of the drainage swale should be accomplished as soon as possible. Stabilization materials can include vegetation or stone/riprap.

Advantages of an Earth Dike
• Can be constructed from materials and equipment which are typically already present on a construction site
Disadvantages of an Earth Dike
• Frequent inspection and maintenance required

Source: EPA (1992)

September 1992

Design Criteria

- Earth dikes are appropriate in the following situations:
  - To divert upslope flows away from disturbed areas such as cut or fill slopes and to divert runoff to a stabilized outlet
  - To reduce the length of the slope runoff will cross
  - At the perimeter of the construction site to prevent sediment-laden runoff from leaving the site
  - To direct sediment-laden runoff to a sediment trapping device.
- When the drainage area to the earth dike is greater than 10 acres, the United States Department of Agriculture - Soil Conservation Service (USDA - SCS) standards and specification for diversions should be consulted.
- Table 4 contains suggested dike design criteria.

TABLE A-1 SUGGESTED DIKE DESIGN CRITERIA

Drainage Area	Under 5 Acres	Between 5-10 Acres
Dike Height	18 inches	30 inches
Dike Width	24 inches	36 inches
Flow Width	4 feet	6 feet
Flow Depth	12 inches	24 inches
Side Slopes	2:1 or less	2:1 or less
Grade	0.5% - 10%	0.5% - 10%

- The base for a dike 18 inches high and 24 wide at the top should be between 6 feet - 8 feet. The height of the dike is measured on the upslope side.
- If the dike is constructed using coarse aggregate the side slopes should be 3:1 or flatter.
- The channel formed behind the dike should have a positive grade to a stabilized outlet. The channel should be stabilized with vegetative or other stabilization measures.
- Grades over 10% may require an engineering design.
- Construct the dike where it will not interfere with major areas of construction traffic so that vehicle damage to the dike will be kept to the minimum.
- Diversion dikes should be installed prior to the majority of soil disturbing activity, and may be removed when stabilization of the drainage area and outlet are complete.

Materials

- Compacted Soil
- Coarse Aggregate

Construction Specifications

- Clear the area of all trees, brush, stumps or other obstructions.
- Construct the dike to the designed cross-section, line and grade making sure that there are no irregularities or bank projections to impede the flow.
- The dike should be compacted using earth moving equipment to prevent failure of the dike.
- The dike must be stabilized as soon as possible after installation.

Maintenance

- Inspect regularly and after every storm, make any repairs necessary to ensure the measure is in good working order.
- Inspect the dike, flow channel and outlet for deficiencies or signs of erosion.
- If material must be added to the dike be sure it is properly compacted.
- Reseed or stabilize the dike as needed to maintain its stability regardless if there has been a storm event or not.

Cost

- The cost associated with earth dike construction is roughly $4.50 per linear foot which covers the earthwork involved in preparing the dike. Also added to this cost is approximately $1.00 per linear foot for stabilization practices. It should be noted that for most construction projects, the cost of earth dike construction is insignificant compared to the overall earthwork project costs.

Sources

- Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
- Maryland Department of the Environment, 1991. 1991 Maryland Standards And Specifications For Soil Erosion And Sediment Control - Draft.
- Storm Water Management Manual for the Puget Sound Basin. State of Washington, Department of Ecology, 1991.
- Cost Data:
  - Draft Sediment and Erosion Control, An Inventory of Current Practices, April 20, 1990. Prepared by Kamber Engineering for the U.S. Environmental Protection Agency, Office of Water Enforcement and Permits, Washington, D.C. 20460.

Drainage Swale

What Is It

A drainage swale is a channel with a lining of vegetation, riprap, asphalt, concrete, or other material. It is constructed by excavating a channel and applying the appropriate stabilization.

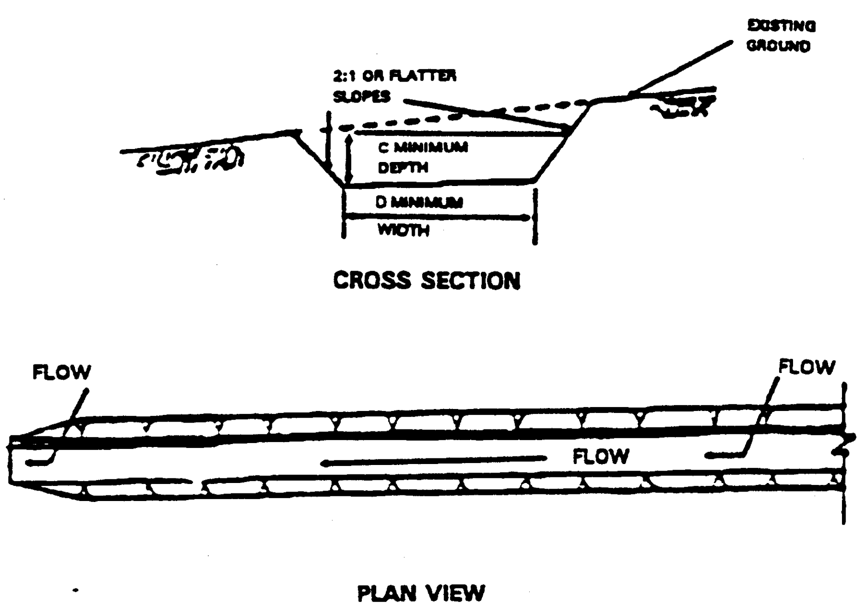

FIGURE A-10 TEMPORARY SWALE
(Modified from Maryland Department of the Environment, 1991)

When and Where to Use It

A drainage swale applies when runoff is to be conveyed without causing erosion. Drainage swales can be used to convey runoff from the bottom or top of a slope. Drainage swales accomplish this by intercepting and diverting the flow to a suitable outlet. For swales draining a disturbed area, the outlet can be to a sediment trapping device prior to its release.

What to Consider

Since design flows, channel linings, and appropriate outlet devices will need to be considered, consult your State's requirements on such erosion control measures prior to constructing a drainage swale. General considerations include:

- Divert the intercepted runoff to an appropriate outlet.

Source: EPA (1992)

- The swale should be lined using geotextiles, grass, sod, riprap, asphalt, or concrete. The selection of the liner is dependent upon the volume and the velocity of the anticipated runoff.

- The swale should have a positive grade. There should be no dips or low points in the swale where storm water will collect.

Advantages of a Drainage Swale
• Excavation of swale can be easily performed with earth moving equipment • Can transport large volumes of runoff
Disadvantages of a Drainage Swale
• Stabilization and design costs can make construction expensive • Use is restricted to areas with relatively flat slopes

Source: EPA (1992)

DRAINAGE SWALE

September 1992

Design Criteria

- Temporary drainage swales are appropriate in the following situations:
  - To divert upslope flows away from disturbed areas such as cut or fill slopes and to divert runoff to a stabilized outlet
  - To reduce the length of the slope runoff will cross
  - At the perimeter of the construction site to prevent sediment-laden runoff from leaving the site
  - To direct sediment-laden runoff to a sediment trapping device.
- When the drainage area is greater than 10 acres the United States Department of Agriculture - Soil Conservation Service (USDA - SCS) standards and specifications for diversions should be consulted.
- Swales may have side slopes ranging from 3:1 to 2:1.
- The minimum channel depth should be between 12 inches and 18 inches.
- The minimum width at the bottom of the channel should be 24 inches and the bottom should be level.
- The channel should have a uniform positive grade between 2% and 5%, with no sudden decreases where sediments may accumulate and cause overtopping.
- The channel should be stabilized with temporary or permanent stabilization measures.
- Grades over 10% may require an engineering design.
- Construct the swale away from areas of major construction traffic.
- Runoff must discharge to a stabilized outlet.

Materials

- Grass seed for temporary or permanent stabilization
- Sod
- Coarse aggregate or riprap

Construction Specifications

- Clear the area of all trees, brush, stumps or other obstructions.
- Construct the swale to the designed cross-section, line and grade making sure that there are no irregularities or bank projections to impede the flow.
- The lining should be well compacted using earth moving equipment and stabilization initiated as soon as possible.
- Stabilize lining with grass seed, sod, or riprap.
- Surplus material should be properly distributed or disposed of so that it does not interfere with the functioning of the swale.
- Outlet dissipation measures should be used to avoid the risk of erosion.

Maintenance

- Inspect regularly and after every storm, make any repairs necessary to ensure the measure is in good working order.
- Inspect the flow channel and outlet for deficiencies or signs of erosion.
- If surface of the channel requires material to be added be sure it is properly compacted.
- Reseed or stabilize the channel as needed to prevent erosion during a storm event.

Cost

- Drainage swale can vary widely depending on the geometry of the swale and the type of lining material:

  - Grass $3.00/square yard
  - Sod $4.00/square year
  - Riprap $45.00/square year

- No matter which liner type is used, the entire swale must be stabilized (i.e., seeded and mulched at a cost of $1.25/square yard).

Sources

- Commonwealth of Virginia - County of Fairfax, 1987. 1987 Check List For Erosion And Sediment Control - Fairfax County, Virginia.
- State of North Carolina, 1988. Erosion and Sediment Control Planning and Design Manual. North Carolina Sedimentation Control Commission, Department of Natural Resources and Community Development.
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